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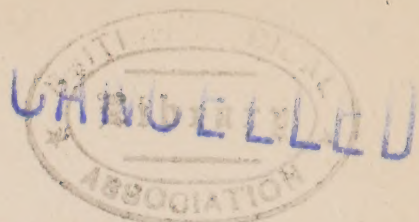


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**DENTAL DISEASES IN RELATION
TO PUBLIC HEALTH.**



DENTAL DISEASES

IN RELATION TO

PUBLIC HEALTH

By

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PREFACE.

THE three communications which go to make up this little book were written in response to requests (1) to present a report on Dental Diseases in Relation to Public Health at the recent International Medical Congress; (2) to open a discussion on Dental Hygiene in Infancy and Childhood at the Annual Meeting of the Royal Sanitary Institute at Exeter; and (3) to open a discussion on Children and Dental Disease before the State Medicine Section of the British Medical Association at their Annual General Meeting, 1912.

They are now published together in order to try to bring home to physiologists and others the importance of a knowledge of the physiology of oral hygiene, a subject which, notwithstanding its overwhelming importance at the present day, is altogether neglected in text-books of physiology. Why such considerations with regard to the physiology of the mouth and teeth have been omitted in the teaching of medical students need not concern us; a change must soon come when the terrible harm resulting from such an attitude towards the mouth and teeth is revealed. It is hoped that a perusal of

the following papers may indicate to many that less harm would have resulted from the omission of the teaching of the physiology of the heart, liver, or any other organ than has resulted from the omission to teach medical students the physiology of oral hygiene.

Considerable progress has already been made with regard to the dissemination of knowledge on this subject through the agency of Medical Officers of Health, School Medical Officers, dentists, and physicians; nevertheless, so long as medical students are not taught the subject, still more, so long as their attention is misdirected with regard to the rationale of the oral secretions, progress in the prevention of dental and concomitant and consequent diseases will be very seriously handicapped. On the other hand, when the physiology of oral hygiene is properly taught, dental caries and consequent and concomitant diseases will soon practically cease to exist in all families which are brought up with reasonable care and intelligence.

J. SIM WALLACE.

150, Harley Street, W.,
November, 1913.

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DENTAL DISEASES IN RELATION TO PUBLIC HEALTH.

CHAPTER I.

DENTAL DISEASES IN RELATION TO PUBLIC HEALTH.

EVER since the investigations of the late W. D. Miller established the connection between various infections and diseased states of the teeth stomatologists have recognized the importance of dental diseases in relation to public health. Further investigation has emphasized the intimate relationship, and the inspection of school children's teeth which has now been carried out in most countries reveals a state of affairs which in itself is dreadful enough, but when considered in relation to concomitant and consequent diseases it fills us with amazement that immediate and strenuous efforts are not being made to remedy the existing state of affairs.

Had the diseases of the teeth been rare and striking in their course, they might have arrested attention

and possibly have been exterminated. But being so very common, so insidious, and so varied in their ultimate consequences, they seldom arrest serious attention. The thread in the story which connects the diseased teeth with more serious or even fatal results is usually so long that the relationship is generally overlooked, except by those who have carefully followed the varied steps which lead from diseased teeth to other and more serious diseases. Thus the extreme commonness of dental diseases, their various modes and channels of infection, and the insidiousness and remoteness of their results, together with absence of knowledge outside stomatological circles, all tend to obscure the inevitable and disastrous consequences which attend the failure of the public and even of the Public Health Service to appreciate the overwhelming importance of dental disease in relation to public health. Not so very long ago the diseases of the teeth were ignored or looked on as trivial, but with increasing knowledge such an attitude is gradually passing away, and now, whether from the point of view of physiology or pathology or even æsthetic considerations, dental diseases are recognized as serious—so much so that among the better class alone millions of pounds are spent annually to try to mitigate the ravages of the disease; and, indeed, now that the diseases of the teeth are recognized to be a constant possible cause of other and more serious troubles, the public conscience has been so far aroused that a universal and

costly dental service for children at least seems to threaten all civilized nations.

THE PREVALENCE AND SERIOUSNESS OF THE DISEASES
OF THE TEETH.

I should like here briefly to direct attention to the diseases of the teeth themselves, for it is sometimes overlooked that national and individual welfare depends to a certain extent on the excellence of the teeth, apart altogether from diseases resulting therefrom. In order to limit the figures we may direct attention to what exists in Great Britain, recognizing, however, that it is merely taken as an example among civilized nations. Let us say, for the sake of having round numbers, that the population is 40,000,000. We know from statistics taken in school children that there are on the average some six to nine teeth decayed or lost in each mouth. We know further, though caries is as a rule less rapid in adult life, that the number decayed or lost is much greater as age advances, so we come to calculate that there are between 250,000,000 and 500,000,000 teeth decayed or lost among the 40,000,000 inhabitants of these islands. If we estimate the value of a sound tooth as compared with a diseased one at £1 (and even in horses each diseased tooth depreciates a horse's value by more than that amount), we come to realize that the loss to the nation from carious teeth alone is represented by hundreds of millions of pounds.

Similarly, irregularities of the teeth which

predispose to caries, oral malhygiene and pyorrhœa alveolaris are present in over 75 per cent. of the population—that is to say, some 30,000,000—and the number of teeth which are pouring pus into the buccal cavity may be estimated, at least has been estimated, at 200,000,000.⁶

It is not my intention to calculate the enormous financial loss to the community that this means, nor the suffering, nor the absences from school or work, nor that men afflicted beyond a certain degree have been unfit to serve their country, either in time of peace or in time of war. We may note in passing that during the South African War 2,451 soldiers were invalided home on account of defective teeth; unfortunately the number invalided in South Africa from the same cause is not recorded. This is no doubt more than five times the number that were invalided on account of tuberculosis, and represented a financial loss to the nation of about £100,000, notwithstanding the fact that soldiers as a class have relatively good teeth, since recruits with very bad teeth are rejected. I am here drawing attention to these facts merely to indicate that quite independently of resulting disease the state of the teeth in civilized countries is of the most serious import, and *per se* requires that public health authorities should do all that little which is necessary to prevent it. For some reason or another the public, however, have till recently considered the diseases of the teeth in themselves as of no great consequence. Now that the

results of the inspection of school children's teeth have revealed the shocking prevalence of the disease, and the South African War and other circumstances have revealed how seriously this could incapacitate individuals; and further, now that the public, or at least public health authorities, have come to appreciate the fact that numerous serious diseases frequently result from diseased teeth, the importance of making the teeth the first object of concern is beginning to be appreciated.

DISEASES RESULTING FROM DENTAL DISEASES

The ideal aim of public health authorities is the *prevention* of disease, and for that reason I may be permitted to omit referring in detail to all the various ailments which result from oral malhygiene and the diseases of the teeth. For the purpose of this report, however, it is necessary to refer briefly to the way in which oral malhygiene and diseased teeth tend to injure health. It is hardly necessary to say that defective teeth impair the power of efficient mastication and the proper preparation of food before it enters into the stomach, and that these tend to impair the first stage of digestion. This is generally recognized.

Nor need I deal with the various diseases, some of them serious, which result from the reflex irritations of diseased teeth, as this forms the subject of another report at this meeting. It is necessary, however, to refer briefly to the modes by which the pathogenic

micro-organisms which inhabit the mouth may gain entrance into the system or interfere with the physiological processes of the alimentary canal.

The most common mode of entrance of pathogenic bacteria into the system is through the pulps of carious teeth. The exposed pulp of a tooth appears to be almost incapable of effective resistance to the entrance of pathogenic micro-organisms, and the further passage of these organisms through the apical foramen is an almost inevitable consequence. Having got beyond the apex of the root a dento-alveolar abscess equally certainly results. The nature of this abscess depends very largely on the nature of the surrounding tissues, the virulence of the micro-organisms which have originated it, and the susceptibility or immunity to the invading organisms which the individual may possess. According to these conditions such dento-alveolar abscess may be serious or trivial in its effect upon the individual; it may remain almost quiescent or burst through the gum and little heed be taken of it by the individual, or it may form a considerable abscess, distorting the physiognomy and give rise to febrile symptoms of a more or less serious nature, or it may result in a diffuse cellulitis (angina Ludovici) or secondary septicæmia and pyæmia with fatal terminations.²⁰ Or, again, the dento-alveolar abscess may invade the antrum of Highmore, and a chronic empyæma may

²⁰ These reference figures refer to Bibliography, page 66.

there be set up and extend to neighbouring sinuses. Naturally the lymphatic glands are always more or less affected, and if or when tubercular bacteria gain a foothold in such diseased glands the enlargement of the gland tends to become more or less permanent and a possible source of infection in the individual.

The next most common mode of entry of pathogenic micro-organisms is through more or less deep wounds—generally speaking, the extraction of a tooth. As a rule, of course, this heals up readily, although cases are on record in which serious results have followed from infection which has gained entrance through such a wound, and even fatal terminations have occasionally been recorded. Possibly from the point of view of public health these acute infections may not be considered of serious import; but we must remember that infection through the apex of the root may safely be said to occur in 75 per cent. of the population, and, except among those who are exceedingly careful in having their teeth attended to, we may equally safely say that such an infection occurs many times, perhaps ten times on an average, in a lifetime. The average duration of the illness caused by an infection through the apex of a root has probably not been estimated; we know that it sometimes lasts in an acute state as a rule for days, sometimes in a sub-acute or recurrent state for weeks or months, and in a chronic state frequently for years. Thus, then, although a fatal termination or a serious illness is relatively rare,

the amount and duration of suffering caused in this way is probably greater when taken in the aggregate than that produced by any other disease, and therefore merits the most earnest attention of public health authorities.

We have another group of diseases of dental origin, namely, those which arise from infective material in, or associated with, diseased teeth by transference of such infective material to more remote parts of the alimentary canal and to ducts entering into it. Although considerably varied in their local and more remote results, there are certain characters common to the diseases of this group; as a rule they result from the prolonged lodgment of masses of micro-organisms of low pathogenicity in situations favouring their undue retention. Thus crypts in the tonsils, folds in the mucous membrane in the pharynx, or a dilated and atonic stomach predispose to the long retention of these micro-organisms. The micro-organisms generally do not enter the system, but rather remain attached to the mucous membrane, giving rise to a low form of inflammation (toxic) and a hypersecretion of mucus. It will be seen, therefore, that these diseases originating in this way are similar in character to the early stages of the disease associated with the teeth from which they generally arise—that is to say, *pyorrhœa alveolaris* resulting from the undue lodgment of masses of non-specific bacteria in the crevice formed by the mucous membrane of the gum and the tooth. Of course, although

masses of micro-organisms may be constantly lodging about the necks of the teeth it does not at all necessarily follow that these masses, when carried into the alimentary canal, will lodge unduly at any particular place and give rise to the diseased conditions just referred to. And it need not astonish us that many people are quite healthy throughout life, although their mouths may have been in a very unhygienic state for many years, or, indeed, during the whole of their lives. In order to gain a suitable soil for their prolonged lodgment and their proliferation at any point beyond the mouth, it is necessary that such part should already have become favourable to the prolonged lodgment of these micro-organisms. Thus after the naso-pharynx has had its vitality depressed by exposure to cold and damp air, or after recurrent catarrhs of the pharynx, and more particularly after the formation of deep crypts in the tonsils, the liability of these parts to retain masses of micro-organisms from the mouth is, of course, increased. Unfortunately, this paves the way still further for the entrance of bacteria of more pronounced pathogenicity, and we find associated with conditions such as we have alluded to the entrance of tubercular bacilli into the tonsil and neighbouring lymphatic glands. Depressed function is another condition which favours the prolonged stagnation of organisms; thus, for example, when the secretion of saliva is arrested more or less completely, an infection of the salivary duct may take place and spread to the

glands⁴ (secondary parotitis). An extension of the infective material may, and frequently does, lead to an infection of the Eustachian tube and more or less troublesome diseases of the ear. Similarly, it is said that the bile-duct may be likewise affected. With regard to the pollution of food, whether it be from the bacteria associated with pyorrhœa alveolaris or necrotic carious cavities, or both, we may safely say that where the digestion is sluggish the presence of enormous multitudes of those organisms interferes with the normal digestive processes, giving rise to symptoms of chronic toxæmia, lassitude, muddy complexion, &c., which are so generally associated with unhygienic states of the mouth. Although these ailments, especially those associated with digestive troubles, are extremely common, they may not be, indeed generally are not, regarded as serious by the public. Those who are troubled with them, however, often find life more or less of a burden, and the fact that they do not give rise to a fatal termination except in rare instances does not justify public health authorities neglecting to do anything which would help to prevent them.

We have briefly reviewed the various avenues through which diseased teeth may, and frequently do, cause many and varied illnesses. It is not necessary to refer to them in detail. The medical profession has already been provided with several monographs on the subject and a *résumé* of them may be found in such standard text-books as the

Messrs. Colyer's "Dental Diseases in Relation to General Medicine." Suffice it here merely to say that most, if not all, competent authorities estimate that at least 20 per cent. of the chronic diseases which afflict mankind result from the diseases of the teeth and the unhygienic state of the mouth associated therewith.

DISEASES OF CONCOMITANT ORIGIN.

So far we have only alluded to the diseases of the teeth and those diseases which result from unhygienic states of the mouth and teeth. There is, however, another important group which we must mention, namely, those which are usually associated with dental diseases, because they result from similar errors. We have contended for years that dental caries must be regarded as a sign of persistent dietetic error, and now, fortunately, we find that medical officers of health and other medical men have taken up a similar attitude. Thus Dr. James Wheatley says dental caries "must be considered as an outward and visible sign of methods of living which produce other and still greater harm."⁴¹ We are all well aware of the effect produced on the teeth by eating of sweets, more especially between meals and before going to bed, and that this frequently induces dyspepsia and anæmia independent of its effect upon the teeth is admittedly also true. So, too, the bolting of food, which robs it of its detergent action

on the teeth, is recognized as a common cause of dyspepsia. In a recent discussion on the ætiology of dyspepsia in childhood Dr. Robert Hutchison says: "Amongst the factors which may produce acquired dyspepsia it is common to attach great importance to dental caries. For my own part I think there is a tendency at the present day to over-emphasize this cause. At all events, I have not been able to trace any constant association between caries of the teeth and the occurrence of dyspepsia. Of greater importance, I think, is the non-use of such teeth as the child has; that is, defective mastication or 'bolting' of the food. That this is a fruitful source of dyspepsia in childhood I think there can be no doubt.

"Of dietetic causes the chief, undoubtedly, is the excessive use of carbohydrates. A diet which contains these constituents in too high a proportion disturbs digestion in various ways, for it is bulky, it is fermentable, and it tends to make too great demands on one class of digestive ferments. Again, a diet which contains too much carbohydrate is apt to contain too little protein, and protein starvation, as is well known, tends to lessen digestive power. It is also apt to be a sloppy diet, which lends itself readily to 'bolting,' and which favours the production of flatulence."¹⁶

In the same discussion Dr. Clive Riviere contended "that dental caries as a cause of dyspepsia was over-estimated. When it did come in it was as tender-

ness preventing efficient mastication and causing bolting of food; but a more important cause of such inefficient chewing was, in his opinion, the absence of training in early life caused through the too long continuance of slops."²⁷ We note from these two quotations that physicians who are evidently not inclined to put too much importance on the state of the teeth as a cause of dyspepsia, yet attribute some of the commonest causes of dyspepsia in childhood to the same errors in diet as we know lead to dental caries. It should be remembered also that the dyspepsias in childhood give rise to malnutrition and several other diseases, such as the neurasthenias of childhood. Further, some physicians now recognize that soft milk-soaked foods do not keep the mouth in a hygienic state, but claim, on the contrary, that these foods are neither directly nor indirectly conducive to the hygiene of the alimentary canal. Thus, Dr. G. A. Sutherland, when referring to the preventive treatment of tubercular peritonitis, says that "the real risk lies in an unhealthy condition of the alimentary canal, which may allow the penetration of the bacilli." He urges the wisdom of a type of diet requiring mastication such as would tend to keep the alimentary canal in a healthy state, and comments on the feeding of children with tubercular tendencies on "a sloppy diet—milk, bread and milk, and pudding." He says: "Experience has shown that this is the worst possible form of treatment." In France, Variot and Lassablière have brought

forward experimental evidence which demonstrates the relationship between various digestive troubles and diseases, and pap-feeding in young animals.* So, again, it has long been recognized that the absence of fresh vegetable juices in early childhood tends to give rise to rickets.

* In a recent paper (*Dental Record*, June, 1913), Dr. F. D. Boyd, Physician to the Royal Infirmary, Edinburgh, was able to demonstrate in a very conclusive way that digestion was performed in a much more satisfactory manner when the consistency of the meal was of such a nature that mastication had to be performed. Thus: "On two days the patients got the same amount of food: $\frac{3}{4}$ lb. meat, 10 oz. bread, and 100 grm. Contrastin. On the first day the food was very finely subdivided and swallowed as a mushy mass. The peristaltic waves occurred in one patient in 1 min. 35 secs., in the second in 1 min. 25 secs. On the second day the same food was taken as grilled steak and toast; in each patient there were ten peristaltic waves in 35 secs. The one meal was mushy, the other required chewing; the constituents were the same, the influence on gastric peristalsis was pronounced. With the mushy meal the stomach turned almost paralysed, while with the meal which required chewing a considerable part was found in the duodenum when the meal was finished. Following the food down the alimentary canal we found that with the mushy food the colon contained little at the end of six hours, while the food which was chewed was well on in the transverse colon in the same time; most of the delay took place in the stomach." The X-ray photographs showed that when a soft, pulpy meal had been consumed the stomach after six hours contained a considerable quantity of the meal, a certain amount having reached the lower end of the small intestine, while six hours after the chewed meal had been eaten by the same patient the stomach was absolutely empty and the entire meal had reached the colon, passing as far as the splenic flexure. Here then we see certain current *inferences* derived from the experimentalist's glass bottle stomachs completely reversed and we observe quite independently of considerations having to do with the teeth that food should not in general be presented to children which does not demand subdivision in the mouth.

At one time it was considered questionable whether the prevention of dental caries by dietetic methods would be justifiable, as it was contended that although the proposed régime might prevent dental caries, the harm that it would do to the alimentary canal might more than counterbalance the beneficial effect which it might have upon the teeth. But far from this being the case, we are now able to claim that the elucidation of the causation of caries and of the dietetic method of preventing the disease, has given physicians the key to the prevention of other common diseases of dietetic origin. Just as a diet which will stimulate the self-cleansing of the mouth in such a way that it will be left in a hygienic state at the end of a meal, so a diet which will keep the alimentary canal in a hygienic state is coming to be recognized as a primary necessity. At one time the value of the food from the point of view of nutrition was practically the sole concern of the science of dietetics. Now, fortunately, the regulation of a meal in such a way that it will not interfere with the physiological functions which keep the mouth and alimentary canal in a hygienic state is more frequently considered. Alimentary malhygiene and associated derangements which follow sooner or later interfere with the nutrition of growing children. It interferes with the physiological functions of adults, and various troubles, such as indigestion, neurasthenia, &c., result. Indeed, we may say that alimentary malhygiene, besides courting infection

from pathogenic micro-organisms, produces a harmful effect from the time of fertilization of the ovum onwards, because if the alimentary canal of the mother is deranged satisfactory conditions of the nourishment of the foetus do not exist. After the birth of the child we find that this is markedly so, for when oral and alimentary malhygiene exist together, with a continuance of the unhygienic types of food which called them into existence, the mother is unable to suckle her child³⁹ and further trouble is liable to supervene. It may be that the increase in insanity is to a certain extent accounted for in this way. At any rate, there certainly is evidence that the neurotic child of the present day is the result of alimentary malhygiene. Other points of interest with reference to diseases resulting from similar causes to diseases of the teeth may be noted. The advocacy of quantities of *milk* and of *sugar* by medical men for children appears to be much less pronounced than it was some half-dozen years ago. Dr. Harry Campbell, while recognizing that properly administered milk and sugar constitute useful foods, says: "It is probable, however (I say this with due deliberation), that on the whole British children get more harm than good both from milk (except in the case of nurslings) and sugar."⁵ The wisdom of long intervals between meals from other than dental points of view is now more generally recognized, and thanks to very careful observations, more especially in Germany, longer intervals between the feeds of infants have been shown to produce

better results than the shorter intervals hitherto more generally advocated.

The diseases which arise from the same errors as give rise to dental diseases are extremely common, serious in themselves, and generally chronic or persistent until the errors are rectified. Notice has not been taken of these diseases in this light till recently, but since the origin of these diseases has been discovered it has been claimed that the revelation of the shocking state of the teeth will be found to have been a blessing in disguise, for not only can we now prevent the diseases of the teeth, but by doing so we prevent other and more serious diseases. Indeed, it may be said that we should follow the rules for the prevention of the diseases of the teeth, even though we were to leave the teeth out of consideration altogether.

DISEASES AGGRAVATED BY THE DISEASES OF THE TEETH.

Many diseases, though not originating from, are frequently considerably aggravated by the diseases of the teeth. Thus dyspepsia, resulting from whatever cause, is obviously liable to be prejudicially affected either because of lack of function of the teeth, or from a swallowing of undue quantities of septic matter mixed with the food, or, as happens most frequently, from a combination of both. Similarly, anæmia of other than dental origin is liable to be aggravated from the chronic toxæmia and septic

absorption which may be associated with the diseases of the teeth and gums. Chronic diseases such as tuberculosis cannot but be prejudicially affected by an insanitary state of the mouth, and nutritious food can hardly be as beneficial for the phthisical patient when regularly passed through a superseptic mouth before reaching the stomach. Typhoid and scarlet fever¹⁵ and other zymotic diseases have been shown to be much more dangerous when the mouth is in a diseased condition. The enormous number of deaths which resulted from typhoid fever during the South African campaign makes us surmise that more deaths may have been caused indirectly through bad teeth and unhygienic mouths than immediately from the deadly hail of bullets from the enemy's rifles. Further comment need not be made on this subject, for it is being recognized more and more what an important factor the state of the mouth is both in health and disease. Indeed, it is said that "in many of the large London hospitals the very first step in the treatment of disease is to have the mouth and teeth seen to." (With good digestion and otherwise good health the diseases of the teeth may be tolerated for many years, if not for a lifetime, but with other organs deranged the necessity for a healthy and functional mouth is doubled.) Similarly, when operations are to be performed on the stomach, or throat more especially, the necessity for a healthy and as far as possible an aseptic condition of the mouth is, or rather should be, recognized. Dr. Dan

McKenzie gives some instructive figures with regard to this point. From an analysis of more than 100 cases operated on for the removal of tonsils and adenoids he was able to show conclusively that one-third of the cases were followed by more or less severe septicæmia. In one case, in which there were both dental caries and pyorrhœa, the patient had a severe and prolonged attack of septic pharyngitis with temperature running up to 104° and 105° , and in another case a fatal termination from septicæmia followed the removal of the tonsils in an adult with pyorrhœa. On the other hand, when the mouth had been put into a hygienic state before the operation no untoward symptoms followed.

Here we may mention that a prolongation of life or a diminished death-rate is not altogether a satisfactory criterion of the healthiness of a community. When considering dental diseases and diseases of dental origin we note the fact that, as a very general rule, they do not terminate fatally. Nevertheless, we observe that dental diseases and diseases of dental origin give rise to more acute suffering and recurrent and chronic ill health than tuberculosis and pneumonia combined. It is fallacious to think that health matters in general need necessarily be all going well when there is a declining death-rate. We know that the death-rate has been diminishing for many years, but, on the other hand, dental caries and what we may call minor ailments appear to have been steadily increasing for the past two generations.

The statistics of the great Friendly Societies may be taken to illustrate this point. In 1901 the annual average of sickness per member of the Hearts of Oak was 1·63 days; by 1910 it had risen to 2·37. In 1900 the annual average per member of the National Deposit Friendly Society was 2·92 days; in 1911 it was 3·34. In 1886 the Manchester Unity of Odd-fellows paid out on an average to each member 17s. 2½d. for sick benefit; by 1910 this sum had risen to £1 os. 4¾d. There has been a steady increase of sickness at all ages.³² When we consider mental vigour we note also that in spite of better housing, more nutritious food and better general hygienic surroundings, there are indications that the proportion of mentally defective individuals has increased during the last generation or two. "The fact that there is to-day one insane person to every 275 normal cannot be regarded as otherwise than very disquieting."³²

ARE THE DISEASES OF THE TEETH PREVENTABLE?

A question of paramount importance in considering dental diseases in relation to public health is: Are the diseases of the teeth preventable? Not so many years ago a very pessimistic answer to this question was given even by the dental profession. The view then taken was that the teeth had degenerated during the course of civilization, resulting in a susceptibility to dental diseases which it was well-nigh impossible

to counteract, and doleful prognostications of a toothless race were often made. The fact that the children of parents with decayed teeth were more likely to have decayed teeth than the children of parents whose teeth were relatively excellent, gave rise to a firm conviction that the diseases of the teeth were so markedly hereditary that no one could even suggest the contrary. Notwithstanding the complete change which has come over the dental profession with regard to the supposed degeneracy of the teeth, the public, and even many members of the medical profession, are still dominated more or less completely by the older views. We may say that the impetuous cry of many medical men for the treatment of dental diseases is based very largely on the assumption that they are practically inevitable as the result of some inherent degeneracy. The diseases of the teeth are regarded by them rather as unpreventable sources of disease than as preventable diseases in themselves, and thus we observe an astounding incongruity in their clamouring for the treatment of the diseases of the teeth while they by their dictates are actively engaged in causing the diseases themselves. To answer this question as to the preventability of dental diseases satisfactorily, we require to refer to a few steps in the evolution of ideas with regard to modern dental hygiene. It may be truly said that preventive dentistry was born with the recognition of the truths of modern biological principles. One of the first and most

important of these principles which caused us to doubt the validity of some of the previously accepted beliefs in the dental profession was that acquired characters were not inherited, and thus the Lamarckian doctrine so generally accepted with regard to the teeth, that the teeth had undergone an hereditary degeneration on account of lack of use, was seen to be an untenable hypothesis. The excellent research of Dr. G. V. Black into the physical and chemical characters of the teeth strongly supported the view that the prevalence of dental disease did not result from degeneracy of the chemical or physical constitution of the tooth. Similarly, the equally excellent investigation of Dr. Leon Williams seemed further to substantiate the belief that there was no degeneracy in the enamel that the highest powers of the microscope could reveal. So, too, his investigation showed that the same defects which were occasionally seen in the teeth of the civilized were present in the teeth of anthropoid apes, notwithstanding their practically complete freedom from dental caries. The biological principle referred to, together with these corroborative evidences of its truth, led us to view in quite a new light the important work of the earlier investigators on the subjects of the causation of dental diseases, and compelled us to come to the conclusion that the hereditary characteristics of the teeth were no more the cause of the prevalence of dental caries now than when caries was an almost unknown disease. A somewhat prolonged research gradually revealed

the fact that the prevalence of dental disease was due to certain errors and changes in man's diet, and that, read in the light of biology, the apparently hereditary nature of the disease was due to dietetic customs in races and individual families. An interesting investigation by Mr. G. Friel was made with regard to the teeth of Kaffirs, which were supposed to be of a peculiarly excellent quality; he was able to show that they were by no means immune to caries when they came to live on the diet of the civilized. Indeed, taking the late R. Mummery's figures to represent the amount of caries found in the teeth of Kaffirs before adopting the foods introduced by the civilized, and comparing them with the figures revealed by Mr. Friel's investigation into the condition of the teeth after civilized foods were introduced, we find that caries has increased 800 per cent. And this, be it observed, notwithstanding the fact that many of the Kaffirs examined had been brought up on native foods in early life. In the light of our present-day knowledge it is curious to note how firmly rooted the theory of the hereditary degeneracy of the teeth had become, and still more curious is the explanation of the supposed degeneracy. A theory satisfying the *amour propre* is very likely to take root—at least, when no other theory exists to explain the supposed facts; and thus the idea became generally accepted that the teeth were degenerating because medical science, dental art, and modern cookery had become so perfect that those with

degenerate teeth, who in a state of nature would have become extinct, were enabled to survive. It would really appear, however, from current ideas on past and even present-day methods, that the artificial substitutes with which dentists supplied these people originally possessed of the supposed degenerate teeth, whether they were vulcanite or metal plates, or even highly-finished bridges, were rather conducive to oral malhygiene and its pernicious consequences than beneficent aids to the continuity of a healthy life. In like manner the refined and, as it were, artificially masticated foods tended to bring about a similar state of affairs. Now that we know the cause of caries we find that rather than being more liable to caries the teeth of the civilized may be really rather less so than are those of savages, because of the smaller size of the crowns of the teeth, the small development of the enamel of the cusps, and consequently the smaller crevices. The light which the teeth of prehistoric man throw upon this subject favours the idea that they were from this point of view more liable to caries than civilized man, and the development of the cingulum, together with a corresponding deep labial pit on the incisor teeth which is so marked a characteristic in *Homo Mousteriensis* Hauseri, indicate how, as far as form is concerned, prehistoric man was more liable to stagnation of food in vulnerable crevices than civilized man. So, too, the diminished size of the upper wisdom tooth, together with its cusps and crevices,

which is characteristic of the highly civilized, we know clinically is less liable to dental caries than the large wisdom tooth, which is more characteristic of the lowest savages and prehistoric man. In other words, during recent ages there has been a gradual but appreciable change in the form, or at least size, of the human teeth, resulting on the whole, to a certain extent at least, from the elimination of those with relatively large teeth and consequent susceptibility to oral mal-hygiene and dental caries.

No doubt there are still those who believe that there are some inherent degenerative changes in the teeth of the civilized which render them specially liable to dental caries. It has, indeed, been maintained in a recent research on the structure of enamel that certain microscopic details in structure were potent factors playing an important rôle in the causation of caries. But when the attempt was made to support this contention with experimental evidence on the *corpus vile*, i.e., the crucial test, they have been constrained to admit that when children are fed physiologically from the point of view of oral hygiene their supposed soft "degenerate" teeth resist caries, even although their teeth had been already still further softened by caries at vulnerable spots.

In England, however, the views of heredity held by the dental profession have in recent years fallen in line with the biological teachings of the present day. Messrs. Bennett, Colyer, Turner, Hopson, and

Mummary have all contributed to the diffusion of more correct views on this important subject; while abroad, Friel, Lischer, and Capdepont have helped to get rid of erroneous ideas with regard to the supposed degeneracy of the teeth. It is rather a pity to have to note that in Germany, the fatherland of the illustrious Weismann, no member of the dental profession seems, so far as I know, to have recognized the important bearings of the ideas of Weismann with regard to the teeth and their diseases. And the possibility of preventing caries by physiological means is apparently still regarded in Germany as unrealizable, just as it was in England ten years ago. Here it should be explicitly stated that although there is no evidence whatever for saying that the teeth in recent generations have become hereditarily degenerate, it is not to be imagined that there are not considerable variations in the form and even the structure of the enamel in different families. We recognize that hereditary variations are reproduced in the offspring, and that these variations do, under certain conditions, predispose certain individuals to caries. Thus cusps may be large and crevices deep in one family, while they are relatively small in the teeth of other families, or individuals; but we have no reason to assume that such variations did not equally exist and persist in our remote ancestors, nor that such variations do not occur in savage races, which are practically free from caries. What evidence there is would appear to show that

the teeth of prehistoric man varied very much as do the teeth of the civilized. And here it may be noted in passing that defective structure and form (hypoplasia) resulting from disease in infancy undoubtedly predispose the teeth thus affected to caries. As the result more especially of Dr. G. V. Black's investigation already referred to, those who still believe in the hereditary degeneracy theory sought to find, and indeed some are still seeking to find, the explanation of the supposed susceptibility of the civilized teeth to decay in certain pathological or abnormal constitutional states of the saliva. To those, however, who could not subscribe to the idea that the increase of caries resulted from inherent causes, the search for an explanation of the supposed susceptibility in pathological states of the saliva was futile. Biological principles seem completely to negative such an assumption, and the theory of evolution indicated what the true explanation might be.

The search for pathological conditions in the saliva as an explanation of susceptibility to dental caries has resulted negatively, and unfortunately has for a long time diverted attention from the more important investigations with regard to the physiology of mastication and the *physiological* processes associated with saliva and mucus in the self-cleansing of the mouth. For a study of these physiological processes revealed the fact that we have it in our power to regulate these processes with diet in such a way that dental diseases may easily be prevented. Although

physiologists gave us little information with regard to the self-cleansing processes of the mouth, and although their ideas on the physiology of mastication were to a large extent erroneous, nevertheless their investigations supplied us with a certain number of facts which, when considered from the point of view of the self-cleansing of the mouth, were of considerable importance in elucidating the perplexing problem of why teeth decayed in one mouth and not in others. Various points which were considered of importance with regard to carbohydrate digestion, were seen to be rather of importance with regard to freeing the mouth from carbohydrates after a meal, and thus the fact that sugar causes a copious flow of saliva was seen to indicate the necessity for its rapid removal from the mouth. Without doubt, starchy foods, accompanied as they almost invariably are in a state of nature by vegetable acids which stimulate a flow of saliva rich in ptyalin, indicate another provision for the liquefaction of starchy material to facilitate its removal from the mouth. So, too, the alkalinity of the saliva facilitates the removal of mucus which may have been precipitated by acid, and at the same time dilutes the acid and counteracts its possible harmful effect on the enamel and finally removes it from the mouth.

Pawlow's work showed us how the saliva was adapted in quality and quantity for the removal of obnoxious substances, *e.g.*, sand, from the mouth. Further observations led me to believe that there was

a special secretion of saliva which I named the "afterflow," varying according to the nature of the meal that had been consumed; that is to say, scanty in amount when bland alkaline foods were eaten, and relatively large in amount and alkaline in reaction when acid foods had been consumed. These views, although ignored by many when introduced some ten years ago,³⁶ have gradually become appreciated and accepted by the dental profession without dispute, and recently have been made the basis of a confirmatory and detailed investigation by Dr. H. P. Pickerill. We may say now that physiological considerations enable us to predict to a certain extent the value of any particular food-stuff in the self-cleansing of the mouth. As a matter of fact, however, before I had noted in detail the physiological principles I have just referred to, I had discovered³⁵ the kind of foods which tended on the one hand to induce dental caries, and those on the other hand which tended to prevent caries, chiefly (1) from a knowledge of the pathology and ætiology of dental caries so far as it had been worked out by Miller; (2) from considerations of the evolutionary history of man and his diet; (3) from clinical and statistical observations with regard to diet among children who were practically free from caries on the one hand, and among children whose teeth were particularly ravaged by caries on the other; (4) from observations on the relative lodgeability of fermentable food-stuffs; and (5) from comparisons of the

teeth and the diet of different savage races. Finally, it may be noted that the most excellent results which have been got by bringing up children on a dietetic régime based upon the knowledge derived from these sources, show beyond all possibility of doubt that dental caries is not only preventable, but that it is easily and surely preventable.³⁸

ÆTIOLOGY.

Before embarking on any scheme of prevention an enlightened public will desire to know what is the cause or what are the causes of dental diseases. Schemes for the prevention of disease generally require money and the public are justified in hesitating before adopting methods advocated by specialists, especially if they involve considerable expenditure of public money, and still more if the expenditure is to be diverted to the specialists who recommend the schemes. If we are able to show that we do know the causes of the diseases of the teeth; if, moreover, we can show that the diseases of the teeth may be prevented without the expenditure of public money, we should have an excellent chance of having our scheme of prevention welcomed by the public. Whether we do know or do not know will best be indicated by discussing the question. For this reason, therefore, a brief *résumé* of the ætiology of the more important dental diseases may now engage our attention. At the same time we

shall note the advance to modern ideas with regard to ætiology during the present century.

HYPOPLASIA.

Hypoplasia, although relatively uncommon and in itself unimportant, is worthy of attention not only because it gives rise to an unsightly appearance of the teeth, but more particularly because it is a predisposing cause of dental caries. It results from malformation of the enamel during its development; it appears almost invariably to be the result of constitutional disease affecting more especially the epithelial structures, and is commonest amongst the children of the poor. Although zymotic diseases are generally credited with its causation, there is no doubt that it frequently, perhaps generally, results from ill-health associated with chronic malnutrition in infancy. When bottle-feeding is not carried out with strict hygienic precautions ill-health is very apt to supervene, and we consequently find that bottle-fed babies are relatively more likely to have this developmental defect. Unhygienic food and surroundings may therefore be regarded as predisposing causes of hypoplasia. It has been noted that certain zymotic diseases are more severe in children whose mouths are in an unhygienic state, and this, together with other evidence, leads us to presume that another of the factors in the causation of hypoplasia is oral mal-hygiene.

THE IRREGULARITIES OF THE TEETH.

Irregularities of the teeth derive their importance in the lay mind chiefly from the fact that they disturb facial beauty; they are, however, far more important from the point of view of oral hygiene, because of their being predisposing causes of mal-hygiene and dental diseases. The ætiology of the irregularities of the teeth may be said to have been non-existent until the present century, but now we are able to outline the causes of irregularities with considerable exactitude. The irregularities of the teeth almost invariably result from an interference with the normal development of the jaws.

(1) From prolonged mouth-breathing and consequent lack of pressure of the tongue on the upper teeth, so that the arch is not broadened and the pressure of the cheeks is not counterbalanced by the pressure of the tongue.

(2) From insufficient development of the muscles of mastication, including the tongue. This generally results from the pappy nature of the food.

(3) From general emaciation, including emaciation of the tongue.³⁷ This generally results from unhygienic feeding or from food which, by not stimulating mastication and the self-cleansing of the mouth, leaves the mouth, teeth, and alimentary canal in an unhygienic state.

(4) From lack of sufficient pressure and strain

during mastication, and concomitant lack of wear of the cusps of the temporary teeth, more especially.

(5) Local causes of irregularities, such as thumb-sucking and remains of temporary teeth which have not been shed at the proper time, need hardly be mentioned, as these local displacements usually rectify themselves with the giving up of the pernicious habit, or the complete shedding of the offending temporary tooth.

At one time it was believed that the irregularities of the teeth did not show themselves till the permanent teeth began to make their appearance; recent investigations,⁹ however, have shown that during the earliest years there is very frequently lack of mandibular and maxillary development, which necessarily results in undue proximity of the temporary teeth and crowding of the permanent teeth when these erupt. Post-normal occlusion is quite a common occurrence²⁴ in temporary teeth before the eruption of the first permanent molar; it would appear, indeed, that the first effort of nature to secure a correct occlusion takes place about the time of the eruption of the temporary incisor teeth. There seems good reason to believe that the instinct which infants have at this period of their life to gnaw is for the express purpose of getting the occlusion of the teeth, commencing with the incisors, correct at the earliest possible date.⁴⁰ When the incisors occlude correctly there generally is little fear of the succeeding temporary teeth taking up abnormal relations to each other. Although

desiring to be as brief as possible, it is necessary to say more about the malpositions of the teeth than some might consider commensurate with their importance, but it must be remembered that the malpositions of the teeth favour putrefactive or fermentative changes according to the localization of the irregularities. In the one case there is a predisposition to the formation of tartar, in the other to the onset of dental caries; further, the malpositions of the teeth frequently predispose to a recession of the gums, loosening of the teeth, and pyorrhœa alveolaris. We may, indeed, say that the prevention of the irregularities of the teeth in childhood is probably the most important factor in the prevention of dental caries, oral mal-hygiene, and pyorrhœa in later life.

DENTAL CARIES.

Limiting ourselves to a few words, we may say that the cause of dental caries is the undue lodgment of plaques or masses of acid-forming micro-organisms together with fermentable carbohydrates, when the acid formed is protected from the action of the saliva by the impermeability of the mass. As abnormal forms of the teeth, malpositions of the teeth, and abnormal relations of the gum and teeth, each and all generally favour the undue lodgment of the food, we note that hypoplasia, irregularities of the teeth, and recession of the gums are all predisposing causes

of caries. Here, indeed, it may be said that, except in the case of the temporary teeth, such predisposing causes, more especially mal-relations of the teeth and recession of the gums, are very important factors in the causation of the disease on account of the many years of persistence of these abnormal conditions.

CHRONIC PERIODONTAL DISEASE.

Pyorrhœa alveolaris is now generally recognized to result in part at least from long-continued irritation of the gingival margin. It seems more than probable that undue lodgment or stagnation of putrescent material at the necks of the teeth, more especially if the gum margin is not closely applied to them, gives rise to inflammation resulting from the absorption of toxins formed in that situation. The effect of the inflammation from toxæmic absorption tends to pass more deeply, causing a rarefying osteitis, and ultimately a loss of the alveolar process supporting the tooth. The onset of this rarefying osteitis is favoured, no doubt, by certain local and constitutional conditions; when the teeth are in normal occlusion and supported normally, mesially, and distally by the neighbouring teeth, and when, in addition to this, the normal pressure and strain of vigorous mastication have developed an alveolar process of a strong and healthy type, little predisposition to rarefying osteitis exists. When, however, the teeth are mal-placed and not normally locked by the occlusion and

by neighbouring teeth, recession of the gums and pyorrhœa alveolaris are predisposed to. Age, too, must be reckoned as a predisposing cause. Tissue change is always going on, and although in the young local toxæmic infection tending to cause rarefying osteitis may be counterbalanced by the activity of the repair, in later life such repair does not keep pace with the loss of bone substance. We may truly say that the building up of the alveolar process is characteristic only of the period of eruption of the teeth and not of the later phases of life. Lastly, the lack of power of eliminating toxins from the tissues must be regarded as a predisposing cause of the disease, and we consequently find that when the organs engaged in the elimination of toxins are diseased, the predisposition to pyorrhœa alveolaris is distinctly increased.

This view of the causation of alveolar osteitis associated with pyorrhœa is supported by the effect of treatment. When assiduous attention is given to cleanliness at the necks of the teeth, the pyorrhœa is reduced to the vanishing point; in fact, as long as the cleanliness is sufficient the disease is arrested. The intractable nature of the disease results from the fact that so long as the teeth remain in their abnormal relation to the surrounding gum physiological cleanliness is really very difficult, if not impossible, to maintain. Healing does not take place, just as an ulcer elsewhere when kept constantly dirty does not heal. But immediately the teeth are removed and

therewith the "pocket" of stagnating material, the disease is invariably cured. Chronic alveolar osteitis and pyorrhœa alveolaris are essentially due to conditions existing outside the system, and so the disease may progress independent of considerations having to do with susceptibility or immunity; nevertheless, the liability of the tissue to invasion by pathogenic micro-organisms is increased by the conditions produced from the chronic absorption of toxins, and from time to time sufferers from pyorrhœa are liable to suffer from a superadded bacterial invasion giving rise to the ordinary phenomena associated with such invasion, among other things increased true immunity to the particular invading organisms and ultimate recovery from such infection. Under the circumstances the gum, periodontal membrane, and alveolar process may become more or less acutely inflamed and the teeth loose, but while these symptoms generally pass away, the pyorrhœa remains.

Although through condensation the ætiology of the diseases of the teeth which I have given is not as satisfactory as it might be, nevertheless enough has been said to indicate that we do know the ætiology of these diseases. We may not be able to elucidate all the details in the ætiology of dental caries or other dental diseases, but as Dr. James Wheatley, who among medical officers of health has studied the subject most fully, says: "I venture to say that the method of causation of dental caries is understood more thoroughly than that of the

causation of any disease of the body.”⁴³ And with this statement I trust that we are all in agreement.

THE PREVENTION OF DENTAL DISEASES.

We have now to note the important fact that the ætiology of dental diseases leads us to recommend methods of prevention which do not in any way divert money into the pockets of the dental profession. Indeed, extremely little money, if any at all, is required; all that is necessary is to reach the intelligence of those in authoritative positions. After this is done the knowledge will rapidly diffuse among the more intelligent classes, and customs become established which will gradually become imitated by the masses who do not think. Of course, an educative campaign at the public expense might be instituted by the medical profession, but inasmuch as it is the duty of a certain class of medical men (medical officers of health) to do what they can to prevent disease, this is already more or less provided for.

When we consider the various dental diseases, their different causes, both predisposing and exciting, together with the erroneous beliefs of the public, we might almost feel inclined to despair of being able to institute the reforms necessary for the prevention of these diseases; but nevertheless by co-ordinating the factors which each of the diseases has in common, and by co-ordination of the factors which are chiefly concerned in prevention, we have been able to devise

a scheme of reform which is extremely simple. And this scheme of reform is made more powerful and urgent by the fact that it has been shown that not only are the diseases of the teeth prevented, and consequently all those that result therefrom, but also that several other prevalent diseases result from the same errors as those which give rise to the diseases of the teeth. We have incidentally referred to the fact that certain food-stuffs are of such a nature as to stimulate mastication and the self-cleansing processes of the mouth. In general it has been found that such food-stuffs are of a consistency which may be termed fibrous in opposition to the type of food which is short, viscous, or pasty, and liable to lodge in the crevices of or between the teeth. The first thing we note with regard to fibrous food is that it stimulates mastication, consequently it stimulates the muscles of mastication and the development of the jaws. Thus the mastication of fibrous food is a factor in the prevention of the irregularities of the teeth. Similarly, we know from ætiological considerations already referred to that the pressure and strain of mastication tend to develop the alveolar processes and to keep the gums in a healthy state. Again, we note that with the abeyance of mastication, either locally or generally, the teeth become coated with masses of bacteria, tartar, and *débris* of various kinds. We note further that the abeyance of mastication tends to make the teeth tender to pressure, and ultimately to give rise to the loosening and falling

out of the teeth. Fibrous foods tend to clean the mouth and teeth both mechanically and physiologically. In the case of animal food (fish, meat, bacon, poultry), the necessity for the complete cleansing of the mouth and teeth after eating these foods is not absolutely necessary from the point of view of the prevention of dental caries—that is to say, even though some shreds of those food-stuffs were retained between the teeth, as they frequently are when the teeth are not well arranged, caries would not supervene. In the case of vegetable food-stuffs, those that are of a fibrous nature are almost invariably accompanied by acid; we have already noted how food-stuffs of this nature clean the mouth chemico-physiologically; consequently, fibrous vegetable food is also antagonistic to dental caries, while derivatives from such food-stuffs (sugar, starch, biscuits, flour, &c.) may be—indeed, very generally are—not only non-fibrous, but potent factors in the causation of dental caries when such substances lodge about the teeth. Fibrous vegetable matter (*i.e.*, cellulose), on the other hand, which is practically unfermentable in the mouth, would not tend to cause dental caries even should it lodge for a time about the teeth, as it occasionally does. We have noted these facts to indicate briefly the possibility of co-ordinating the factors which are instrumental in preventing dental diseases. It is not sufficient, however, to make somewhat abstract generalizations and to expect the public to appreciate and follow them; it is necessary

to reduce our knowledge to simple rules which can be understood by all, and although the reduction of a complex subject to simplicity may not be easy, yet we may claim that it has been done. It is important in doing this to focus the attention more especially on the subject engrossing the attention of the public most fully. For this reason it is well when framing short rules for the guidance of the public to rivet attention on dental caries more especially, and further to direct special attention to young children. The following rules will indicate how the subject can be brought into a few words which are easily intelligible to the public generally.

IMPORTANT SHORT RULES FOR THE PREVENTION OF DECAY IN TEETH AND ASSOCIATED DISEASES.

(1) *During the first two and a half years of life all starchy or sugary food (except milk) should be given in a firm or fibrous form*, so as to stimulate mastication and insalivation, and thus to promote the healthy growth of the jaws and the regular arrangement of the teeth. Bread, rusks, or any other farinaceous food should never be added to or soaked in milk. Bread with crust (and butter), toasted bread (and butter), should form a considerable part of the solid part of the meals habitually given to children of this age. As the infant passes from the milk diet to the more solid diet the milk should be more and more

diluted with water. During this period also the solid food should be eaten first, and the milk and water taken after.

(2) *After the age of two and a half years children should always have a considerable amount of the farinaceous food in a form which will stimulate a pleasurable amount of efficient mastication. The albuminous part of their diet should also be presented in a form which will encourage mastication, e.g., boiled fish, meat, and later, bacon. Milk or milk substitutes should only be allowed in small amounts.*

(3) The meals should be arranged in such a way that if soft, starchy, or sugary food has been eaten, the mouth and teeth will be cleansed by food of a detergent nature taken immediately after. Thus, therefore, when sweets of any kind, e.g., milk puddings, jam rolls, cake, sweet biscuits, bread and marmalade or jam are eaten, fresh fruit should be eaten afterwards.

(4) *Three meals daily are to be preferred to any greater number, as the longer the interval the more hygienic is the state of the mouth and stomach, and therefore the more perfectly adapted for the reception of a further meal. Sweets, chocolate, or biscuit and milk should never be eaten between meals or before going to bed.*

When these rules for the prevention of decay in teeth cannot be observed, some attempt should be made with a small tooth-brush to clean the crevices of and between the teeth after every unhygienic meal,

but as this is *extremely difficult to do effectually* without injuring the teeth or gums, it is advisable to have children who are brought up in this way taken regularly to the dentist from the age of three onwards every six months till the teeth become crowded and irregular; thereafter the visits may require at times to be more frequent until all the natural teeth have been replaced by artificial substitutes.

FOOD-STUFFS AND DENTAL CARIES.

NOT CLEANSING AND LIABLE TO INDUCE DENTAL CARIES.

Farinaceous and sugary food in general without fibrous element.

Examples: Sweet biscuits and cake; bread and marmalade; bread and jam; new bread without crust; bread soaked in milk; milk puddings; porridge and milk; preserved fruit; chocolate and sweets of all kinds; honey.

Liquids: Cocoa and chocolate.

The above foods should not be eaten except when followed by foods of the cleansing kind.

CLEANSING AND PREVENTIVE OF DENTAL CARIES.

Fibrous foods generally.

Examples: Fish, meat, bacon, poultry, uncooked vegetables, lettuce, cress, radish, celery. Cooked vegetables are as a rule cleansing, but in a less degree than uncooked vegetables.

Stale bread with crust; toasted bread of all kinds; twice baked bread; pulled bread and cheese.

Savouries; fresh fruits, especially those requiring mastication, *e.g.*, apples; fatty foods, *e.g.*, butter and margarine.

Liquids: Tea (preferably Russian fashion), coffee, buttermilk, water, also soups and beef-tea.

On account of the universality of its use in civilized communities, and the fact that it forms a very large part of the diet of the poor, it is desirable to note some of the reasons for referring to bread as tending to induce dental caries in certain forms, and as helping to prevent it in other forms. We recognize that all cooked farinaceous foods may induce caries; it would, however, be an objection to the practicability of modern methods of prevention to have to exclude bread from the dietary except when followed by other more detergent foods, because with the very poor at least, questions of economy in nutrition take precedence over questions with regard to the hygiene of the mouth. For this reason we must not exclude bread in its least harmful form, and fortunately we need not do so. In my earliest experiments I noted that toast was very liable to lodge in the crevices of the teeth, and recognizing its fermentability, made the deduction that it was to be regarded as decidedly conducive to caries. The fact that toasted bread does lodge in such situations and is highly fermentable is true, but the inference that it is specially conducive to caries is not admissible. Clinical evidence—which, by the way, in these matters is statistical evidence—did not substantiate the belief that toasted bread was specially liable to induce caries. Furthermore, it has been noted that perfect teeth in young children are more frequently found among the poorest classes. When we noted that such children are brought up very largely on bread, it led to a modification of our

views on the cause of caries. We may refer to these modifications. The fact of fermentable carbohydrates lodging in the crevices of the masticating surfaces of the teeth does not necessarily tend to induce caries at these spots, because vigorous mastication may have completely dislodged the plaques or masses of bacteria which are necessary for the production of sufficient acid in immediate contact with the enamel. The fermentation which may be going on on the mass of lodging bread remote from the enamel of the tooth is of relatively little importance with regard to the induction of dental caries in the crevice over which the bread may be lying, because the acid formed is at some little distance from the enamel under such circumstances. Then we have come to note that the easy escape of acid from the lodging mass on the one hand, and the permeability of the lodging mass by saliva on the other, is of considerable importance, for if the lodging mass is spongy and permeable by the saliva, any acids which may be formed near the enamel of the tooth are relatively easily neutralized, and as bread, more especially toasted bread, stimulates the flow of and absorbs a considerable amount of saliva, it swells up, and is therefore somewhat spongelike; for this reason also it is not specially liable to cause caries when the teeth are well arranged. On the other hand, if bread is soft and moist, or soaked in milk, mastication effectual in the self-cleansing of the teeth cannot be performed, the bacterial plaques on the masticating surfaces of

the teeth are not removed, the lodging food-stuff lodges over the bacterial plaques, and so the relation of the bacteria to the carbohydrate is most favourable to the destruction of the tooth by the acids formed. When, in addition to this, jam, marmalade, or syrup is consumed with the bread, the lodging food-stuffs are or become viscous, and so while inhibiting the action of the ptyalin tend to prevent the saliva from neutralizing the acid formed in the crevices of the teeth, and the diffusion outwards of the acid formed in these crevices. Further, bread when taken in a pappy form does not stimulate mastication, the primary function of the teeth is in abeyance, they become coated with bacterial plaques and food particles and mucus, and where carbohydrate food is not rubbed into this coating there is a tendency for tartar to accumulate, giving rise in general to an unhygienic condition of the mouth.

THE VALUE OF TREATMENT.

It is unnecessary for me to dilate on the value of treatment of dental diseases; that we all regard as obvious, and moreover the educated public recognizes the value of treatment, even though at times some are remiss in having it carried out for themselves. There is another reason why we need not insist upon the value of treatment; it is that there now exists a large and influential class of practitioners whose interest it is not only to treat dental disease,

but continually to remind the public of its value, and as in the past, so in the future, they will no doubt continue to do so. In this report, however, it is necessary to take an unprejudiced attitude, and to refer not only to the benefits of treatment, but also to the limits there may be to these benefits.

With regard to the treatment of dental caries in its early stages we may say that, apart from the infliction of pain, this is one of the most satisfactory operations which is performed on the human body—that is to say, if the operation is well performed, and if the conditions which tend to bring about a recurrence of the disease do not exist or are prevented from existing. Unfortunately, human nature being what it is and what it will continue to be, it is not our lot to have to deal with caries only in the early stages. Too often a feeling of pain is required to urge some people to apply for dental treatment, and too often we have not to deal with caries in the early stages, but after the pulp of the tooth has been involved by the disease. Nevertheless, the treatment of caries after the pulp has been invaded is generally a very satisfactory if tedious and possibly painful operation. No doubt a small percentage of failures occur even in the hands of the most expert operators; no doubt it is not ideal to leave dead roots in the mouth. At the same time, on the whole we recognize that this is in general a satisfactory operation. With regard to orthodontics, we are unable to say that the procedures are as a rule satisfactory; the operations

for the regulation of the teeth are generally tedious, expensive, and apparently good results are liable to relapses. Moreover, the operations are seldom devoid of risk of injury to the periodontal membrane, and we seldom see a case of marked malpositions of the teeth restored to the perfection which is characteristic of the normal. This is the more unfortunate because the normal arrangement of the teeth is of primary importance in the prevention of dental caries and of effective and lasting treatment.

The treatment of recession of the gums and pyorrhœa alveolaris is, unfortunately, by no means all that could be desired. When recession of the gums and pyorrhœa have developed the alveolar process and the gums can never, except in the earlier stages, be brought back to the normal.

It is true that great benefit can be got from constant cleansing of the teeth and the pockets round the teeth by skilled hands, together with assiduous attention on the part of the patient to prevent an unhygienic state of the mouth and teeth, more especially at the gum margins. If or when it is possible to prevent undue stagnation of bacteria and their products in these situations the disease does not progress, but as the tendency for *débris* and bacteria to collect in these situations is abnormally great, cures, if they may be so called, are rare. Nevertheless, with constant attention and periodical visits to a competent operator, great benefit can be derived not only in preventing the progress of the disease,

but also in actually curing certain diseases which are more or less completely dependent upon the state of the mouth. In general it may be said that the diseases of the teeth tend to recur unless modern preventive methods are practised in early life. Caries is very liable to recur, if not at the site of a filling, at some other part of the tooth, or in some other tooth, and similarly with pyorrhœa.

When treatment is relied upon without further preventive methods than can be got from the use of a tooth-brush and antiseptic mouth-washes, it is recognized that such treatment to be satisfactory must be almost annually repeated. It is therefore a costly proceeding, although admittedly the benefit derived does in general justify the large expenditure of money which it necessarily entails. Compared with modern methods of prevention, however, treatment must be regarded as a failure. Hypoplasia may as a rule be prevented, it cannot be cured; irregularities of the teeth may be prevented without any increase in the cost of living; if they are not prevented they can only be ameliorated at great expense. Caries may easily be prevented, but the treatment of caries does not prevent a recurrence of the disease. Recession of the gums and pyorrhœa may be prevented, but the treatment is relatively supremely unsatisfactory.

There are different institutions for treatment with different values. The treatment of the private practitioner should be the most satisfactory; the patient comes, or should come, regularly to him, year after

year, so that every trouble as it arises may be put right in the early stages. The private practitioner takes a pride in his work, and is thus interested in prevention, as if he is not his work is liable to be undone by recurrence of the disease. Hospital treatment being as a rule under the control of distinguished operators, and having for its object the training of students not only in the best methods of treatment, but in prevention also, is capable of doing, and does, excellent work. And though the operations may be performed at little or no cost to the patient, they are not any discredit to the dental profession, nor do they tend to make the public under-estimate the value of treatment. For not only are the best methods of treatment and the higher ideal of prevention kept before the student, but inasmuch as such student is about to go out and enter into practice, he may become a centre for the dissemination of the knowledge which is requisite for the prevention of dental diseases. The last institution for treatment to which we may refer is the school clinic. This is liable to be much less satisfactory. An enormous amount of work is expected from the operator, and the best work may not be done. The regulation of the teeth is practically never seriously attempted in school clinics, and the work becomes simply a repetition of extractions and hurried fillings. The value of the work done is largely gauged by a lay committee, who think not of the perfection of the work, but merely of the number of fillings and

extractions that have been performed. To do many fillings in an hour is easy if they are not intended to last, but if lasting fillings have to be done, time and patience on the part of the operator and the child are absolutely necessary. Nevertheless, such work as is done must do some good to the recipients of the treatment, and if the annual re-treatment which seems hitherto to have been necessary in some 75 to 80 per cent. of the children is given, an appreciable benefit is conferred upon the school children during an important part of their life. It is a pity that the teaching of the more important rules of prevention has so far been neglected in school clinics. If these rules are taught in the future, lasting good will result from the teaching given, instead of only temporary relief from treatment.

ECONOMICAL CONSIDERATIONS.

It is not necessary to discuss here whether it is or is not wise to *prevent* the diseases of the teeth; we are all agreed on this point. The question we have to discuss is how dental diseases may be most efficiently and economically prevented. We have referred to the rules which require to be enforced for their prevention. Two or three points may be here noted with regard to economy. Firstly, it is no more expensive to eat the solid part of the meal first and finish with the liquid part, than it is to take both solid and liquid together, or to take the

solid well soaked in the liquid, as some experts still recommend young children to take their bread and milk.

Secondly, if mastication requires to be performed on suitable food, the bacteria of the mouth or in the food are not allowed to locate themselves and cause trouble. And thus, to a certain extent, foods stimulating thorough mastication and insalivation do not require the same amount of care with regard to sterilization as food which tends to stagnate about the teeth or other part of the alimentary canal. Milk, which is so generally recommended for children, is not only an expensive food, but it is both troublesome and consequently expensive to sterilize.

Thirdly, if there is, as there ought generally to be, sufficient variety in the meal, it is not any more expensive to have the arrangement of the meal or the sequence of the foods conducive to oral hygiene than conducive to oral mal-hygiene.

Fourthly, fruit is no more expensive when raw than when cooked and mixed with sugar; in fact, all cooking really means expense. Moreover, to soften the cellulose and mix it with quantities of sugar decreases the value of the food-stuff from the point of view of oral hygiene. With regard to cellulose and water, which so constantly accompany vegetable foods, they are practically devoid of expense; yet the expense that is sometimes gone to in order to avoid cellulose in the dietary might almost induce us to imagine that it was to be regarded as an irritant poison rather than

as a gentle stimulant to the normal functions of the mouth and alimentary canal generally.

And, lastly, let us refer to the fallacious doctrine that sugar may be regarded as a cheap food and as a protein sparer. The food of poor children is necessarily very largely composed of bread or other cereal food-stuff. It is from this source that they are compelled to derive practically all their protein. It necessarily follows that they have a surfeit of carbohydrate. To advocate sugar in any form for such children shows how far an obsession for caloric values may lead the dietetic specialist.

Unfortunately, the almost exclusive absorption which present-day physiologists have with regard to the nutritional value of foods, and lack of appreciation of their hygienic values, is soon transferred to the equally unphilosophical or unthinking public. An incident which occurred in my practice some time ago will indicate how the most careful mother may be misled by the teachings of those who were considered authorities in dietetics. A mother brought her little boy of five years of age to me to have his teeth attended to. I looked into his mouth, and soon observed that he had scarcely one tooth free from dental caries. I told his mother that there would be very little use in my filling his teeth unless she altered his diet. She replied that she had been most careful with regard to his feeding, and when I told her that that was probably why his teeth were decaying so rapidly, she asked what more she could do. I turned

to the boy and asked him if he would like to finish his meals with an apple. The boy replied, "I don't know." I said, "Surely you know whether you like apples or not!" He said, "No, I have never tasted one." I then turned to his mother and asked if really he had never tasted an apple. She said, "No, the doctor told me that apples were not nutritious."*

Another economical consideration must be mentioned. If the diseases of the teeth are prevented, the hundreds of thousands, perhaps millions, of pounds which are spent on their treatment would be saved. So, too, if the diseases of the teeth are prevented, the millions of pounds which are spent on the treatment of diseases resulting from diseased teeth would be saved. And again, when physiological methods of prevention are established, the millions of pounds spent on the treatment of the diseases of concomitant origin will be saved.

WHAT HAS BEEN DONE.

For many years the dental profession tried to prevent dental caries by inculcating the regular and assiduous use of the tooth-brush and antiseptic or

* An indication that the teachings of the dental profession rather than those of dietetic specialists are being recognized by the public may be gathered from the following piece of news: "At last the English apple, the best of all apples, is coming into its own, and the area under fruit is increasing rapidly each year. It is, perhaps, the only English crop that is increasing, and some parts of the country will soon be solid orchards without a break for miles."

alkaline mouth-washes, together with, be it noted, annual or six-monthly visits to the dentist, but the beneficial results of such methods with regard to prevention were not so marked even in those classes who practised the régime most carefully. And although advocated as a means of prevention, it was admitted that the diseases of the teeth continued to increase rather than diminish.

In recent years, however, effective preventive measures have been instituted, and the results of such measures as have already been recorded have been remarkably successful. In their private practices a considerable number of dental surgeons have made a beginning in teaching their patients to avoid the errors which bring on caries and other dental diseases in childhood. Unfortunately, dietetic habits are often formed before the dentist is consulted, and prejudices with regard to food and feeding are not always alterable at a moment's notice. Moreover, patients look to their medical adviser rather than to their dentist for guidance with regard to matters concerned with diet. Nevertheless, patients are generally impressed with the simplicity and wisdom of the dietetic régime now advocated by modern dentists, and aided by the instinctive preferences of the children it has generally been possible to get the majority of patients to carry out the dietetic principles advocated, more or less thoroughly. It is difficult to say how many members of our profession have been advocating the new system, but inasmuch as the new views are

explained in the more recent text-books, such as Colyer's "Dental Surgery and Pathology" and Bennett's "System of Dental Surgery," and as, moreover, several dental surgeons holding influential positions in the teaching schools were advocating these principles before these books were published, we may surely say that some thousands of children have during recent years been benefiting, and probably tens of thousands of teeth have been saved from becoming carious. At one time 75 to 80 per cent. of the children required re-treatment one year after having had their teeth put in order by their dentists. Now, however, those dentists who are enthusiastic in explaining the new preventive methods find that less than 25 per cent. require re-treatment a year after they have had their teeth put in order. Moreover, there is an increasing number of children being brought up from the earliest years on the new régime who never require treatment at all. It is, however, to the progress that is being made among those who hold a special position of authority that I would particularly direct attention—that is to say, to the work that is being done by medical officers of health and school medical officers. In his report for 1910, the chief medical officer of the Board of Education, Sir George Newman, writes: "There are few questions of greater moment calling for the attention of the health and education authorities of this country than this one of diet, both in relation to teeth and to the general nutrition of the child. The problem

concerns both the most suitable forms of food and the best methods of feeding at the different periods of life. A suitable and sufficient diet is one of the most pressing requirements in relation to the national life." And again, in the same report, he says: "Speaking generally, not more than a few children out of every hundred will be found who fail to bear evidence of present or past dental disease. What, however, is of even greater moment is the fact that probably the majority of school children suffer more or less serious disability in some form or other, sooner or later, from dental decay. Indeed, it is probably true to say that there is no single ailment of school children which is responsible, directly or indirectly, for a larger proportion of the delicacy and disease (including constitutional disease) which are found at every turn to handicap efficiency, both physical and mental."

Sir George Newman, as has been pointed out, further sums up very tersely the views of the more responsible members of the dental profession as to the cause of dental caries. The importance of his report can hardly be over-estimated, coming from the chief medical officer of the Board of Education, and going to the school medical officers of England, who are in such authoritative positions in their own spheres. The influence which such a report wields is no doubt very great, but independent of this report the relationship of the diseases of the teeth to public health has been occupying the attention of prominent

medical officers of health and school medical officers throughout England. And here mention must be made of the important work among school medical officers which has been done by Dr. James Wheatley. After studying the question for himself and re-echoing the belief of those of us who maintain that the impending triumph of medicine will result from recognition of those physiological principles which prevent the diseases of the teeth, together with all consequent and concomitant diseases, he brought the subject forcibly before the general medical practitioners in his county. He then gave a series of lectures to the school teachers, and finally prepared leaflets for the instruction of the parents of the school children in his county.

Dr. Wheatley's more recent contributions⁴² indicate that further study has only strengthened his belief in the importance of oral hygiene with regard to public health. He thinks it will be conceded that it is no exaggeration to say that the prevention of dental diseases "would do more for the improvement of the health of the people than the extermination of any other disease, even tuberculosis." And in his fourth annual report to the education committee of the Salop County Council, which was welcomed as a model report by Mr. William Rushton, the editor of the *Dental Record*, he says: "I am more than ever impressed with the fact that in the prevention of dental caries and oral sepsis is the greatest field for personal preventive medicine at the present time."

Other medical officers of health and school medical officers throughout England, realizing the importance of the prevention of dental diseases, are doing similar excellent work, and there is no doubt that the reform in dietetics which is necessary for the prevention of dental diseases is already well begun. Only a few years ago medical practitioners hardly thought of the possibility of really preventing the diseases of the teeth. Impressed by the then prevalent beliefs in the inevitability of these diseases, they could only be got to listen to those who insisted upon the value of treatment. Now, however, they have become much more interested in, and anxious to listen to those who advocate modern preventive methods. Indeed, at a recent annual meeting of the State Medical Section of the British Medical Association, and also at a meeting of the Society of Medical Officers of Health, at each of which meetings I was invited to read a paper, the medical officers present were most unanimous in their agreement with my contention that treatment could never be of much more than temporary utility, and that the only satisfactory method of solving the problem was to carry forward the campaign of prevention along physiological lines.

Furthermore, the editorial staffs of medical journals have done much to bring the new principles of dietetics, which have been shown to be so simple and effectual in preventing the diseases of the teeth, before the general medical practitioner and the

writers of books on dietetics. We have now many medical men who recognize to the full the fundamental importance of the new principle of dietetics, which claims that the meals should be of such a nature or so arranged that they will leave the mouth in a hygienic state. It is noted in medical circles that "in the last few years the diet of children has been entirely reconsidered. Much of the traditional feeding has been rejected, and in its place a carefully-thought-out dietary based upon scientific principles has been established."¹¹ Writers on diet in childhood have been severely criticized by medical men for neglecting to teach the new principles. The importance of the subject is indeed so far appreciated that it is claimed that the future of the nation's health depends upon the recognition of the new principles. It is further pointed out that the eminent simplicity and good sense of the principle make it certain that the campaign, revolutionary though it is, will ultimately be successful. And here the work of the National Food Reform Association may be mentioned, for through the influence of a conference held, and a book subsequently published by it,* the subject has been brought before almost all the more important public and secondary schools in England, and beneficial reforms in the dietaries of several of these schools have already been made. So, too, we may just refer to the fact that medical writers in the

* "Our Children's Health at Home and at School."

lay press have brought forward the new views, and although the influence of these writers has been largely undermined by the conflicting counsel of the advocates of older methods, yet it may be presumed that they have done good in so far as they have tended to counteract the effect of the erroneous prejudices which for many years have caused a progressive increase in the amount of the diseases of the teeth. Unfortunately, the harmful result of erroneous teaching does not cease immediately the harmful teaching is stopped; thus the mistaken ideas advocated by high authorities in the past are blazoned in advertisements at the present day, and foods are extolled in such advertisements because of their high nutritive qualities without the slightest regard as to whether the foods are of a hygienic nature. And as if to give a scientific seal to their wares, these are prepared after the manner of laboratory products, chemically analysed and labelled, not for their effect on the human body, but for their conformity with certain laboratory tests.

WHAT REQUIRES TO BE DONE.

It is realized by many medical officers of health and others who are in positions of authority that efforts to inculcate physiological methods of prevention will be largely nullified so long as erroneous teachings with regard to dietetics emanate from high quarters. One cannot but admit with Dr. J. H.

Gibbs that "one of the great obstacles to progress along this line was the ignorance, apathy, and even opposition of so many general medical practitioners. One had only to glance at any orthodox book on dietetics to see that the whole teaching was calculated to produce not only dental caries, but gastro-intestinal and other disturbances. Naturally one could not expect the average general practitioner to be more enlightened than the dietetic specialist, but one must recognize the fact that until medical men discard the suppositions upon which the present teachings of dietetics are based, dental caries and many other children's ailments would flourish." Nevertheless, although there are indications in some of the recent books dealing with dietetics, more especially in childhood, that the new views which were introduced primarily from considerations of the teeth are being recognized, a great deal yet remains to be done.

In general, then, we may say: That it is of the greatest importance that the erroneous teachings of the past should be put an end to. As it is those who are in authoritative positions whose teachings produce by far the greatest effect, so we must primarily direct our efforts in such a way that their teachings, instead of being harmful, will become beneficial.

From this it follows: Firstly, that the physiology of oral hygiene must receive due recognition and be taught to medical students in the future. Let me indicate more definitely. We have all been medical students, but what were we taught with regard to

the physiology of mastication and the functions of the saliva? Were we not taught that mastication consists of grinding the food with the teeth and having it "collected, enveloped in saliva into a mass or bolus, which rests upon the back of the tongue and is carried backwards to the aperture which leads into the pharynx?"¹⁷ This teaching was by no means correct, and the fact that the mastication of suitable foods was conducive to the cleanliness or hygiene of the teeth and mouth was not referred to. The function of the saliva was described with regard to the digestion of starch in the mouth, which is, as we know, almost negligible in amount during mastication. We were not taught that the principal function of the saliva is to ensure a hygienic state of the mouth and teeth by pouring out upon the food saliva which would ensure or facilitate the complete removal of such foods as are injurious to the teeth, should they remain in the mouth. Thus, for example, the reason for the copious flow of saliva when sugar is taken into the mouth was not referred to, and although we were taught that much sugar hampers the action of the saliva, the importance of this with regard to oral hygiene, or rather mal-hygiene, was never mentioned.

Secondly, it is necessary that the fundamental principles of biology, including, of course, the important subjects of evolution and heredity, upon which our methods of prevention are primarily based, shall be taught efficiently and sufficiently to medical

and dental students, so that specialism or prejudice shall not misdirect attention and undo any of the beneficial teachings which have led to the establishment of simple but effective means of preventing dental and concomitant and consequent diseases. It might be thought that after the ætiology and the means of preventing dental caries had been elucidated there would be but little fear of retrograde ideas. But this is not so. If biology is not taught better than it is at present at some of our universities, we shall have energetic young graduates outmarking Lamarck—that is to say, maintaining that the teeth may degenerate in one or two generations for lack of use, or contrariwise maintaining that we shall require one or two generations of food requiring thorough mastication to restore our teeth to the excellence of our forefathers'. Such crude Lamarckian doctrines may be revived to explain the supposed degenerate conditions of the teeth of the civilized, and, dominated by such beliefs, methods may be devised to show that the teeth of the civilized have degenerated. By the aid of the microscope molehills may be made into mountains, the vulnerable crevices which in the smaller civilized teeth are not quite so large as in the larger teeth of savages, may easily be left out of the field of vision, and the pernicious deduction that the teeth of savages are less liable to lodge food unduly and become carious may be made. Furthermore, by attempting to write about things of which an elementary knowledge is not possessed, the learned

profession of medicine may be made to look ridiculous in the eyes of the scientific and philosophical. These are not imaginary possibilities, as those of you who have been following recent literature are well aware.

Thirdly, general knowledge must not be made subservient to the teaching of special subjects at universities. Specialized training and the teachings of specialists are apt to cause confusion; it is therefore desirable as far as possible to teach what is necessary from a point of view of preventing dental diseases by deduction from general principles. So far as prevention is concerned it is quite unnecessary to teach medical men any more details of odontology than are already taught in the classes of human and comparative anatomy; it is quite easy to teach the science of dietetics without reference to details of odontology at all. The discovery of the means of preventing dental caries and many other diseases resulted more from philosophical deductions based on the fundamental sciences than from specialized investigations, and the teaching of the means of prevention should to a great extent follow on similar lines. Moreover, the teachings of specialists must always be co-ordinated and consistent with the teachings of the fundamental sciences, and not detailed instructions having little or no regard for the general scheme of things.

Fourthly, pathology must be taught to medical students in such a way that the general truths or conceptions thereof shall not be impaired or

complicated by neglecting to recognize the nature of dental and periodontal diseases and their relation to other diseases. There is certainly no need to increase the amount taught to medical students. All that is required is that the errors in the teachings of the past shall be replaced by correct teachings. When that is done, medical officers of health, school medical officers, stomatologists, and dental surgeons will have little or no difficulty in inculcating correct methods of living, and dental and concomitant and consequent diseases will rapidly become almost completely exterminated.

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CHAPTER II.

THE PHYSIOLOGY OF ORAL HYGIENE.

IT was my good fortune to be discussing the question of oral hygiene with a distinguished medical officer of health about a year ago, and he put to me the question : “ In what book on physiology are the principles of oral hygiene most satisfactorily elucidated ? ” To this I had to make the reply that as far as I knew the principles of oral hygiene were neither elucidated nor referred to at all in any books on physiology. Nevertheless, physiologists have long been acquainted with many of the facts upon which the principles of oral hygiene are based, and for these we are indebted to them.

To understand properly the physiology of oral hygiene it is necessary to refer to the physiology of mastication, for although the chief function of mastication is the preliminary preparation of food in order to facilitate its digestion, it has a secondary function in that when suitable foods are masticated it cleans the teeth and facilitates the action of the saliva in doing likewise. It should be noted, however, that many food-stuffs which are consumed at

the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth or between the dorsum of the tongue and the hard palate, and is then swallowed. This method of mastication—if mastication it can be called—is, as a rule, adopted for custards, fine meal porridge, soft puddings, and soft non-fibrous foods generally.

When there is a certain amount of coarse or fibrous matter in the food-stuff, then the process is essentially different, and mastication is performed in a more thorough manner. In this latter case the food is crushed and torn between and heaped on to the masticating surfaces of the teeth by the muscular contractions of the tongue, cheeks, lips, and motions of the lower jaw. During comminution between the teeth, the juices of the food-stuffs, the saliva which becomes incorporated, and the suspended non-fibrous part, are pressed out from the fibres and gradually collect during the process on the middle of the dorsum of the tongue, which is gradually hollowed out for the reception of such food, and this part is then swallowed. The fibrous part of the food, however, is subjected again and again to the crushing and disintegration between the teeth. If any of the fibrous part passes towards the back of the dorsum of the tongue, it is arrested by the pressure of the tongue against the rugæ of the palate, and while the fluid and finely comminuted part gets sucked or pressed back into the hollow formed at the back of the

dorsum of the tongue, the coarse and fibrous parts are thrown between the teeth and subjected again to crushing, squeezing, and comminution. The rough surface of the tip and dorsum of the tongue and the smooth-ridged palate are especially well adapted for this separation of the food prepared for swallowing and that which requires further mastication.

When for any reason mastication is not performed on one side of the mouth the teeth on that side become coated with mucus, tartar, and food *débris*. It is evident, therefore, that mastication of fibrous food is conducive to dental hygiene. Now let us turn our attention to mucus and saliva. Mucus is important as a lubricant, and, mixed with saliva, a vehicle for the removal of food particles. It lubricates the mucous membrane and teeth on the one hand and the food on the other, thus facilitating the passage of the food from one part of the mouth to another during mastication. Being of a sticky and tenacious character, particles or shreds of food are, as it were, caught or roped and pulled backwards down the throat with each act of deglutition. Thus, therefore, food of a particulate or shreddy nature is relatively easily removed from the mouth. When the food is not of a short, pasty, or viscid character the mucus, generally speaking, ensures its complete, or practically complete, removal from the buccal cavity. The mucus is in general secreted in amounts proportionate to the requirements of the particular kinds of foods for this purpose. Likewise the saliva facilitates

the same physiological processes, and the quality and quantity secreted is also, generally speaking, proportionate to the requirements of the food consumed. Saliva has also a marked effect in preventing acids taken in food or developed by bacteria from decalcifying the enamel, and this effect seems to be much greater than could be accounted for simply by its power of neutralizing the acid. Mucus is freely miscible with saliva, so that even if mucus has no similar power in protecting the enamel from decalcification, it does not hinder such beneficent action of the saliva. The variations in the amount and quality of the saliva and mucus corresponding to the quality of the food consumed appear to be common to all, whether "susceptible" or "immune" to caries. That this is so is not a subject of controversy, but nevertheless the fact that the normal physiological processes supply with marvellous ingenuity the means of securing the cleanliness of the mouth and teeth seems to be most persistently overlooked by many who believe that the mouth is clean, or otherwise, according to whether it has or has not been brushed with a tooth-brush.

At one time it was taught that the function of the saliva was to digest starch. To a slight extent this is no doubt true, but by far the most important function of the saliva is to keep the mouth in a hygienic state. Substances which might be noxious to the teeth if they remained for a considerable time in the mouth are, as a rule, rapidly got rid of by the

saliva, and in general we may say that the saliva is secreted in quantity and quality proportionate to the necessity for the removal or control of substances obnoxious to the teeth. Thus, accordingly, sugar in the mouth causes a copious flow of saliva, yet sugar is not digested by the saliva, and the rationale of the copious flow is to get the sugar out of the mouth and prevent it from doing harm. Similarly, acids call forth a copious flow of saliva. If acids were retained in the mouth without dilution or neutralization by the saliva, injury might be done to the teeth. But special provision is made for the prevention of such injury, for not only does the acid call forth a copious flow of saliva, but it also tends to precipitate the mucus on the unrubbed surfaces of the teeth, which hinders the acid from doing harm to the enamel. Over and above this an after-flow of alkaline saliva is induced which helps to clear the mucus, which has been disorganized by the precipitation of the acid, together with food particles and bacteria, away from the teeth. Then, again, dry foods stimulate the flow of saliva, for their removal is facilitated in this way. On the other hand, liquids of a neutral or alkaline character do not stimulate the salivary secretions. They are easily swallowed—that is to say, passed out of the mouth without the aid of saliva. If the foods were of what we may call a natural kind the mouth and teeth would always be clean, and the teeth would remain free from caries as the teeth of animals do, but on account of cookery and the artificial

refinement of food, the natural self-cleansing processes of the mouth are frequently stultified. Thus, for example, sugar may be so concentrated as to hinder the action of the saliva, the fibrous part of the food may be so thoroughly eliminated as to make mastication impossible, while farinaceous food may be so viscous and refined that after it is plastered into the crevices of the teeth the saliva may be unable to remove it before injury is done to the teeth. Most vegetable foods, especially fruits, very generally associate cellulose, sugars, acids, aromatic and even acrid principles, and it is scarcely right to consider the effects of any one of them when dissociated from the others. They naturally supplement each other in oral hygiene. Thus, while the cellulose, on account of its physical nature, is arrested in the mouth and disintegrated by the teeth, the acid and aromatic principles stimulate the flow of saliva and help to loosen the cellulose framework. Further, the aromatic taste often remains in the mouth and continues to stimulate the flow of saliva even after the food has been swallowed. It was for food-stuffs as they were presented in nature to man and his ancestry that his organization was most perfectly adapted, and it does not necessarily follow that a concentrated extract of any such food is necessarily harmless to the teeth or even the mucous membrane of the mouth.

Having now considered the nature of the process of mastication together with the qualities of the

mucus and saliva, we may classify and refer to the different physiological processes which under normal circumstances and the aid of a physiologically correct diet, keep the mouth and teeth in a hygienic state.

Firstly, we have the *mechanical* process. This depends, to a great extent, on the physical consistency of the food. When the food is of a firm and somewhat fibrillar consistency, it stimulates the pleasurable activity of efficient mastication. The teeth and gums are rubbed and scoured, particles of food are dislodged from the teeth, expressed from the bolus of food, sucked or pressed back towards the pharynx, and swallowed. In other words, food of such a consistency has a detergent effect. Highly refined or "short" and soft food has, on the contrary, a different effect when taken into the mouth; it is simply crushed or squashed into the crevices of the teeth, and if it is at all of a sticky nature it remains impacted there. Bread and jam and cake may be taken as examples of such foods which tend to lodge about the teeth.

Secondly, we have the *chemico-physiological* process. Food, when taken into the mouth, stimulates a flow of saliva, and carbohydrate food, especially if slightly acid and firm in consistency, stimulates the secretion of saliva rich in ptyalin. The mastication helps to incorporate the ptyalin in the food, and the solid starch becomes converted into soluble sugar, which is ultimately swallowed in a liquid, or nearly liquid, form. This is, of course, the natural method

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of treating carbohydrate food, and, it may be said in passing, is the physiological method of leaving the mouth free from carbohydrates at the end of a meal. It should be remembered, however, that much sugar hampers the action of the ptyalin.

Thirdly, we have the *hydrodynamical* process. With each act of mastication the saliva is mixed with the food, forced in certain directions between and about the teeth, between the food shreds, and ultimately it, together with dissolved and suspended particles, is swallowed. We may note here, again, that if the food is soft or pappy this hydrodynamical process is practically lost, as such foods do not stimulate efficient mastication.

Lastly, we have a *saprophytic* process. In the whole history of man or animal the mouth has never been an aseptic cavity, and the bacterial flora of the mouth seems to play an important part in its hygiene. There is no pepsin or other ferment in the mouth which can digest or liquefy the various albuminous shreds which are apt to lodge between the teeth. But there are many of the mouth bacteria which have this power. In fact, these bacteria digest and liquefy the albuminous shreds which lodge about the teeth, and so allow of their dissolution. They give rise to a continual disintegration and removal of food particles, and tend to keep the teeth clean at those very situations which are not kept clean by the natural friction of the food, tongue, cheeks, and lips.

I do not say that all the bacteria which may be in

the mouth are beneficial, for even some of those which have the power of liquefying albuminous matter have also the power of producing acid when the lodging food is of a starchy or sugary nature. The strictly liquefying mouth bacteria, however, seem to be quite innocuous to the teeth, and if the dietary is arranged physiologically the beneficial mouth bacteria are favoured; while, on the other hand, the harmful—the acid-forming—bacteria are, in my opinion at least, prevented from proliferating. It appears that, when acid-forming bacteria produce a certain amount of acid, this acid itself arrests their further growth. Thus, therefore, weak acids in foods may be presumed to have a like effect on the acid-forming bacteria.

As far, then, as oral hygiene is concerned a physiologically correct meal requires, firstly, that it should contain a reasonable amount of food of a firm or fibrillar nature which will necessitate efficient mastication, and thereby remove all bacteria plaques or masses from the masticating surfaces of the teeth. For if bacterial plaques or masses are allowed to remain on the masticating surfaces of the teeth, viscous or finely ground carbohydrate food would tend to lodge in the crevices of the masticating surfaces and so induce dental caries. Secondly, a physiologically correct meal should terminate with some food-stuff which is of a detergent nature or at least not liable to lodge in the crevices of or between the teeth. For this purpose we are limited to

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savouries, to pulled bread with cheese and celery, followed by water or some more refreshing drink, preferably slightly acid and aromatic, or to fresh fruit.

Notwithstanding these alternative terminations, it will be found in practice with numbers of children that the best and most suitable termination, and the termination which children most relish, is fresh fruit. Nothing is more conducive to the hygiene of the mouth except, perhaps, raw vegetable foods, so that fresh fruit should practically always form part of the routine dietary of healthy children, and after fresh fruit has terminated the last meal of the day (which should not be taken just before going to bed) nothing should be allowed except water.

Here, perhaps, a word may be said with regard to how fruit is conducive to the hygiene of the mouth. For our purpose we may say that fruit is made up of a fibrous part holding in its meshwork the sweet, aromatic, and acid juices which are so agreeable to the palate. When fruit is masticated, the more or less liquid part contained in the fibrous meshwork is expressed and swallowed, while the fibrous part is again and again subjected to crushing and disintegration between the teeth. At the end of the process the disintegrated fibrillar mass is practically tasteless. The sweet juices have been swallowed first, while the more fibrillar part has been stimulating mastication, insalivation, and the dislodgment of food particles. The fibrillar part of the fruit may

be likened to a mop which, through the influence of the acid and aromatic juices, is able to call forth a copious flow of alkaline saliva, which is forced in all directions about and between the teeth so as to cleanse them thoroughly. Furthermore, when the fibrous remains are swallowed an after-flow of alkaline saliva completes the further flushing out of the mouth.

CHAPTER III.

CHILDREN AND DENTAL DISEASE.

IN recent years it has been shown that there is no disease so prevalent as dental caries. There are few troubles of longer duration than are those of the teeth, for very frequently they begin in the cradle and only end with the grave. In addition to this, it is recognized that dental ailments sooner or later give rise in some form or another to more or less serious maladies. Many widely different diseases, ranging, for example, from dento-alveolar abscess to cancer of the tongue, may result directly from diseased teeth, while those resulting indirectly know no limits. Furthermore, dental diseases frequently interfere with the normal development of the individual. This abnormal development naturally is most marked in the jaws, and it is safe to say that nine-tenths of the ugliness in the lower half of the face, which is so common at the present day, would straightway disappear were normal development not interfered with. The results of dental diseases are not always eradicable by medical treatment, and the amelioration

of dento-facial ugliness is tedious, expensive, and most frequently not altogether satisfactory.

These are not the only reasons for directing attention to dental diseases in children. Not so many years ago dental diseases were supposed to be hereditary and practically unpreventible; now they are known to be almost invariably preventible, and the whole outlook on the means of prevention has accordingly been reconsidered. The foregoing considerations make the prevention of dental disease of primary importance, for if we prevent the diseases of the teeth, as we now know we can, many diseases, whether concomitant or consequent, will seldom occur and the fabulous sums of money which are at present spent on their treatment may be used for far better purposes.

It is not my intention to go into the question at all fully as to how dental disease, and more especially dental caries, may be prevented. That is, perhaps, fairly well known to all who are engaged in the prevention of disease, and I have recently tried briefly, yet sufficiently, to explain this elsewhere.¹ Modern methods of preventing decay in teeth are based on a knowledge of the ætiology of the disease. This has been very thoroughly studied, debated, and elucidated by the dental profession; but as a result of a disastrous omission from the medical curriculum, medical students are still kept in the most profound ignorance of the subject. It is now known that dental caries results from the undue lodgment of plaques of micro-

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organisms, together with fermentable carbohydrates, when the acid formed thereby is protected from the action of the saliva by the impermeability of the mass. This being so, we now recognize a new principle in dietetics—namely, that the food should be of such a nature, or the meals so arranged, that the mouth is left physiologically clean after food is eaten.

All animals, except those kept in captivity by man and subjected or restricted to unhygienic meals like children, have their teeth kept free from disease in this way, and no reasonable individual would say that the meals should be of such a nature or so arranged that the mouth will be kept in an unhygienic state. Yet this is what the dictates of those who have been teaching medical students dietetics have led to, and the deplorable result on the teeth is what no doubt compels this Section to seek to study the subject for itself, and see whether the remedy suggested by the dental profession is correct or not. Now, the modern methods of prevention have been as astonishingly successful as the remedy is simple, and the parrot's cry that we will not get people to adopt it is belied by the fact that we do get people to adopt it, and adopt it most willingly. Certainly, children are enthusiastic in its adoption, especially when fresh fruit after meals is supplied them. Moreover, they undoubtedly would prefer that the money, whether taken from the parents' pocket direct or extracted by the State, should be spent on fruit or some cleansing food-stuff, than that it should be spent

on extracting, stopping, or regulating their teeth. In fact, after an experience of more than ten years of modern preventive methods, I can unhesitatingly say that the change to hygienic methods of feeding is welcomed by nine-tenths of the parents, as well as by a like number of the children, and were it not for the erroneous dictates which were established in ignorance of the principles referred to and preached with the assurance bred therefrom, two-thirds of the diseases of the teeth would rapidly vanish without further trouble.

Some of you may be somewhat incredulous, and at one time the great bulk of the dental profession was so, too; but even my claim that not only can caries be prevented, but that by modern methods it can be, and has been, arrested,² has not only been confirmed, but there is now little or no incredulity with regard to it at all. It is, indeed, recognized as obviously true, for it is seen that what takes place occasionally by chance can certainly at times be brought about by design now that we know the rationale of the prevention of the disease.

It may be said that modern preventive methods have been tried by set design only by the more intelligent and well-to-do classes, and it has been objected that the poor cannot afford to have their meals arranged in the simple but effective manner that has proved to be such a reliable method of preventing caries. Here it may be admitted that there will at first be some little difficulty. With the poor we can

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hardly hope to adopt the simple method of finishing a meal with a specially cleansing food-stuff as a routine procedure so long as it is regarded as expensive. Fortunately, however, the limitations which poverty itself enforces do also enforce to a certain extent hygienic foods and methods of feeding, and the fact that the very poorest children have more frequently good teeth than the richest indicates the truth of this assertion.

I would here like to refer to two of the main factors in the causation of dental diseases, and you will notice that the very poor are more generally likely to fare well than those better off. One of the factors in the ætiology of caries is the pappy nature of the food which very young children are so frequently compelled to subsist upon. The soaking of bread in milk costs more than they can afford, and, moreover, the preparation of the pap is more troublesome than simply giving a young child a piece of bread to eat. The second point is that the very poor children have but few pennies to spend on sweets. This is an important matter, and, thanks to the excellent work of the medical officer of health for Salop, Dr. James Wheatley,³ we are able to bring home this truth more effectually now than we ever were before. It is evident, from his statistics, that the eating of sweets by children is responsible for 50 per cent. of the decayed teeth in children at the present day. Think what this means. When accurate statistics have been taken, it has been shown that each school child

has, on the average, some five to nine carious teeth. Let us put the average number at six; then a simple calculation leads us to the conclusion that there are some 21,000,000 teeth in a state of ruin simply through eating sweets. It may be said that sugar is a cheap and excellent food for the poor. Statements of this kind are frequently even printed in medical books. But let us analyse the matter. Because of their poverty the poor cannot buy beef, mutton, and other foods of an albuminous nature; they are very largely compelled to get the protein they require from bread; in fact, the poor live very largely on bread. For this reason they always tend to get a surfeit of carbohydrate if they get sufficient protein from this source. So we conclude that every penny spent on sugar as a food is practically wasted, or at least is only as justifiable as sending coal to Newcastle.

What is so often wanting in the diet of the very poor is sufficient protein, sufficient fat, and sufficient fresh vegetable juices, all of which are very helpful in keeping the teeth free from caries. But it may be said that our efforts in preventing children eating sweets will be of little avail. They certainly will be of little avail so long as the great authorities on dietetics are flooding the sources of information with reasons for regarding sugar as an important and inexpensive article of diet, ignoring at the same time its disastrous results and failing to indicate how sweets may be eaten without harm resulting. It is also difficult to prevent children after they reach

school age from wasting their money on sweets if they have been brought up on pap, for pap-feeding causes a pathological craving for sweets. I have frequently called attention to the fact that children brought up on what we may call the physiological system have not got any marked liking for sugar; rather have they a marked liking for fish, flesh, fruit, and fat. In reference to this point Mr. George Thomson, in calling attention to the fact that the perverted taste for sweets was the cause of a great amount of dental caries, said, "Children who had been properly brought up did not naturally like sweet things, and he had abundant evidence on that point from all parts of the world."⁴

I need not pursue this part of the subject further. Suffice it to say that there are two things required to be done: (1) The fountains of erroneous dictates have got to be dried up; (2) the truth has to be brought home to parents with regard to the proper feeding of children, more especially during the first few years of life. Medical officers of health are in a far better position to do this than dentists, and until it is done the problem of the prevention or treatment of dental disease is utterly hopeless.

Now let us consider the treatment of dental disease in children. Together with the inculcation of true methods of prevention this is very desirable, but treatment is frequently advocated without any regard to prevention beyond tooth-brush drill, and few seem to have realized how futile and expensive such a

method of procedure is. Roughly speaking, we may calculate that there are some seven million children in Britain between the ages of 3 and 15 who require dental treatment. It is safe to say that on the average six teeth are carious in each child; in addition to this 50 per cent. of these children have their teeth crowded and irregular. Let us assume that it were possible by some prodigious effort to call into existence a sufficient number of dentists qualified to do the work efficiently—that is to say, to restore the teeth, and not simply to mutilate the dental arch by extracting them. Let it further be assumed that it were possible for these dentists to put every child's mouth into thorough repair within three years; we may as well give them three years to do the work, because even first-rate operators sometimes take a year or two to complete the regulation of the teeth of a child, and it is important that the efficient regulation of teeth should be done, because if it is not throughout life there will be a distinct predisposition to dental caries, oral sepsis, and in later life pyorrhœa alveolaris. Let us assume that all this can be done for £1 per head; that is, 6s. 8d. per annum per child for the first three years—and this is a ridiculously low estimate if the work is to be done fairly thoroughly—then in three years there will have been an expenditure of some £7,000,000. As, when dental treatment is performed without modern preventive measures being taken, 75 per cent. of children require re-treatment at the end of one year, at the end of three years, then, the

treatment will all require to be recommenced and approximately the same amount voted to be uselessly thrown away, and so on *ad infinitum*. Here let me say that you may bemoan the cost of dental operations. You may, perhaps, get them done, in a way, on the cheap. But I venture to think it will be found that cheap dentistry is painfully dear in the long run.

In the past the well-to-do have chosen to go in for this method of procedure—that is to say, treatment *plus* the tooth-brush—but there is no indication that dental disease among the well-to-do has been appreciably reduced. It is certainly not claimed that each successive generation is freer from dental disease because in each successive generation the treatment has been more thoroughly performed and the tooth-brush more rigorously insisted upon. Correspondingly there is no evidence that the expenditure on dental treatment in the upper classes has been decreasing. The difficulty, if not impossibility, of raising the funds necessary for treatment has led some to fold their arms and do nothing, but in so doing they are doing a grievous wrong. It is the duty of at least a certain branch of the medical profession to do what they can to *prevent* diseases, and because the treatment of dental diseases cannot be undertaken as fully as they would like, this is no excuse for neglecting their opportunities in the way of prevention. Moreover, it is contended, and with truth, that it is only by prevention that the problem of the eradication of dental disease can be hoped for.

Without expense the campaign for the prevention of dental diseases in children may at once be undertaken by medical officers of health. At one time I thought it would be advisable to have someone with expert knowledge of the means of preventing the diseases of the teeth to supervise the dental reports of school and health medical officers, but so long as such men as Dr. Newsholme and Sir George Newman are at the heads of their respective departments this seems unnecessary. To all intents and purposes, then, the knowledge and machinery already exist which are requisite for the prevention of dental disease, and were it not that many medical men regard the diseases of the teeth not as diseases in themselves of appreciable consequence, but rather as a source of originating disease, preventive measures would have been instituted years ago. But now that it is recognized by medical officers of health that "dental caries must be considered as an outward and visible sign of methods of living which produce other and greater harm," such an attitude can no longer be maintained. Gentlemen, some are born great, some achieve greatness, and some have greatness thrust upon them. The State Medical Service was born great because it was born of the idea of prevention. This service will certainly achieve greatness by the work it is doing, and will do, in preventing dental diseases. Assuredly it should not wait till this crowning achievement is thrust upon it. One thing is certain—the greatest triumph of preventive medicine will be

in preventing dental and concomitant and consequent diseases, for this includes more than half of the diseases from which man suffers ; and though dentists may derive some satisfaction from having elucidated the means of prevention and from having initiated the movement, yet the honour of making the campaign a brilliant and complete success will undoubtedly rest with the medical officers of health of Great Britain.

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